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A Curious Fluid and an Electric Jolt Deliver a Magic Carpet Ride

By JIM McCRAW

If you can remember back to grade-school science class, you may recall the amazement of seeing what a horseshoe magnet does to a pile of iron filings, arranging the powder in orderly patterns and holding it neatly in place.

That is a fair approximation of what happens inside the shock absorbers of some recent cars from General Motors, including the Buick Lucerne, Chevrolet Corvette and several Cadillacs.

As in most suspension systems, the shock absorbers of these cars control the motion of the wheels by forcing fluid through a series of internal passages. But rather than depending on specially calibrated valves to regulate the fluid flow for varying road conditions, G.M.'s system uses a peculiar substance called magnetorheological fluid that transforms from a free-flowing liquid to a thick syrup in the presence of a magnetic field.

G.M. did not build the system it calls Magnetic Ride Control to demonstrate its Mr. Wizard cleverness. Instead, the shock absorbers were developed with Delphi, a major parts supplier, to minimize one of the most troublesome trade-offs in the engineering of a new car - the compromise between ride comfort and cornering ability.

G.M. says it is the industry's fastest-acting suspension, able to fine-tune its settings in a thousandth of a second, or about once every inch at 60 miles an hour. The system continuously adjusts the shock's resistance to up-and-down movements, maintaining a soft setting on smooth roads for a comfortable ride but stiffening the action when needed to control wheel movement or limit body lean.

The secret sauce inside the shock absorbers or suspension struts is a silicone-based fluid that contains iron spheres ranging from 3 microns to 10 microns in diameter. (A human hair is about 100 microns in diameter.) The liquid becomes very thick when surrounded by a magnetic field - its viscosity can change from that of thin oil to a peanut butter consistency, Delphi says - and increases resistance to the shock absorber piston that moves up and down as the wheel encounters bumps.

The change from a free-flowing liquid to a soupy goop is carried out by rearranging the iron spheres suspended in the fluid. When no magnetic field is present, the spheres are randomly dispersed, but when the current is applied to electromagnets inside the shock absorber, the spheres line up, following the magnetic field just as iron filings do at the north and south poles of a horseshoe magnet. The magnetic force attracting the spheres to each other gives the fluid its molasses consistency.

The ride system uses electronic position sensors at each wheel to measure how far the wheels move up and down relative to the car body. A smooth surface causes little wheel motion, but when a larger or faster motion is detected, it is counteracted with electric current dealt out by the system's central processor - up to five amperes of current to make the fluid more resistant to flow and stiffen the shock's action.

The system's computer also receives input from sensors that monitor the car's direction of travel and the steering wheel angle, and from the antilock brakes and traction control.

Using this data, the computer is able to signal the suspension not only how much damping force is required for the road conditions, but also to control body lean when cornering and to prevent the front end from diving under hard braking. Over all, the design goal of the system is to maximize the amount of tire tread in contact with the road, which benefits handling and safety.

The magnetorheological fluid is produced by the Lord Corporation of Cary, N.C. Lord's technology is also used to damp the up-and-down motions in the driver's seats of tractor-trailer trucks and in artificial limbs, but only G.M. is using it in auto shock absorbers.

The first production car to use this suspension system was the 2002 Cadillac Seville STS, and the next year it was standard equipment on the 50th anniversary edition of the Corvette. Cadillac's XLR roadster uses the technology and the SRX crossover wagon offers it as an option; in neither case can the driver adjust the setting. The '05 Corvette and Cadillac STS have driver-selectable suspension settings for touring and sport driving modes.

On all but the \$75,000 XLR, magnetic ride is an option, costing \$1,695 on the Corvette and between \$6,920 and \$13,000 on the Cadillacs, bundled with a long list of other options and not available separately.

The ride system offers a much wider range of soft-to-hard damping than conventional shock absorbers, and better control of vehicle motions for a flat ride and precise handling, said Jim Mero, a suspension engineer at G.M. who led the team that engineered both the Cadillac and Corvette systems. He also said that the shock absorbers were so sturdy and simple that they should last the life of the car.

Mr. Mero says this technology allows G.M.'s ride and handling engineers developing vehicles to fine-tune the software instructions that control the shock absorbers at the keyboard of a computer. They can then program the ride and handling characteristics more precisely.

To demonstrate the abilities of the magnetic ride system, G.M. arranged a drive of several vehicles at its proving grounds in Milford, Mich., about 40 miles northwest of Detroit. A 2005 Cadillac STS with conventional shock absorbers, driven to establish a baseline for later comparisons, rode quite well over the entire, horribly bumpy test course at speeds up to about 45 miles an hour. Faster than that, the ride was very harsh and noisy - especially at the Big Bump, a deep pothole the length of a Chevy Suburban.

An STS sedan with the magnetic ride system set to the touring setting negotiated the entire course at speeds over 60 m.p.h., with little sensation of roughness at the steering wheel and little harshness coming up from the tires.

Switching out of the luxury cars and into a pair of low-slung Corvettes showed similar advantages for the system in a sports car. The Corvette with magnetic ride control was easy to drive over the same course at speeds nearing 85 m.p.h., including the Big Bump.

Finally, Mr. Mero rolled out an ominous-looking all-black SRX, and with a wry smile said, "Now try this one." The tall SRX, equipped with a prototype of the ride system's next generation, was stable, quiet and comfortable around the entire course - at speeds nudging 100 m.p.h.

Delphi and G.M. are reluctant to talk about specific applications for the magnetic fluid in future products, but hint that it has the potential to be useful in clutches and vibration-absorbing engine mounts.